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Houston, Texas 77058

SPACE SHUTTLE
AEROTHERMODYNAMIC DATA REPORT

(NASA-CR-167378) SPACE SHUTTLE AFRSI OMS PODS/JOINTS DEVELOPMENT TEST USING MODEL SPECIMENS AND MODEL 81-0 TEST FIXTURE IN THE AMES RESEARCH CENTER 9X7 FOOT SUPERSONIC WIND TUNNEL (OS304B) (Chrysler Corp.) 45 p 00/16

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SPACE SHUTTLE AFRSI OMS PODS/JOINTS DEVELOPMENT TEST USING MODEL 116-Ø SPECIMENS AND MODEL 81-Ø TEST FIXTURE IN THE AMES RESEARCH CENTER 9x7 - FOOT SUPERSONIC WIND TUNNEL (OS304B)

by

J.G.R. Collette

Rockwell International
Space Transportation and Systems Group

Prepared under NASA Contract Number NAS9-16283

by

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New Orleans, Louisiana 70189

for

Engineering Analysis Division

Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas

WIND TUNNEL TEST SPECIFICS:

Test Number:	ARC 97SWT 501-1
NASA Series Number:	OS304B
Model Number:	116-0,81-0
Test Dates:	17 June 1981 to 29 June 1981
Occupancy Hours:	34

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SPACE SHUTTLE AFRSI OMS PODS/JOINTS
DEVELOPMENT TEST USING MODEL 116-Ø
SPECIMENS AND MODEL 81-Ø TEST FIXTURE
IN THE AMES RESEARCH CENTER 9x7 - FOOT
SUPERSONIC WIND TUNNEL (OS304B)

by

J.G.R. Collette
Rockwell International STS D&P Division

ABSTRACT

An experimental investigation (OS304B) was conducted in the NASA/Ames Research Center 9x7-Foot Supersonic Wind Tunnel from June 17 through June 29, 1981. The purpose of the test was to subject Advanced Flexible Reusable Surface Insulation (AFRSI) specimens to an environment simulating the flow characteristics encountered at the OMS pods of the Space Shuttle vehicle during ascent and to evaluate the AFRSI joints in this environment.

Two pairs of AFRSI specimens, one pair with a light fabric face cover and the other with a heavier covering, were subjected to the same two tests: a calibration test and a life test in a compression corner flow environment. Of each pair, one test pad was instrumented for calibration purposes.

The heavy fabric specimen lost some insulation material after 97 minutes (194 missions) of the planned 200-minutes life test. The light-surfaced test article failed after 150 minutes (300 missions).

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INTRODUCTION

Advanced Flexible Reusable Surface Insulation (AFRSI) is presently under consideration as a potential replacement for the Low-Temperature Reusable Surface Insulation (LRSI) tiles on the Space Shuttle. The AFRSI is a quilted blanket consisting of silica fiber felt insulation material with a quartz fabric OML cover and a glass fabric IML lining. The quilting is done with quartz thread stitched through the three layers of material. The blanket IML is bonded to the skin of the vehicle while the OML face is exposed to the high-pressure gradients, fluctuating acoustic pressures, and wind shear stresses attendant to atmospheric flight. The blankets are pliable, but individual fibrous elements are hard and brittle, and susceptible to damage, especially where they cross each other. Therefore, the durability of various AFRSI configurations in the presence of pressure gradients and turbulent airflows requires investigation.

The purpose of the test was to subject AFRSI specimens to an environment simulating the shock, pressure gradients, and turbulence characteristics encountered at the orbiter OMS pods during ascent. A second objective was to evaluate AFRSI joints in this environment.

The test was conducted in the NASA/ARC 9x7-foot supersonic wind tunnel from June 17 through June 29, 1981. Eight runs were completed during 34 hours of occupancy.

The test articles consisted of two pairs of AFRSI specimens, one with a light fabric cover and the other with a heavier covering, all configured to the same pattern. Of each pair, one test pad was instrumented for calibration purposes while the other pad was subjected to a life test.

Compression corner flow characteristics with attendant flow separation and unsteady shock patterns were created at specific areas of the specimen by deflecting a flap located at the trailing edge of the pads. The calibration test consisted of sweeping the flap deflection from 32.8 to 55.7 degrees for each of three dynamic pressures in the 500 to 900 psf range, at a constant Mach number of 1.8. Static pressures on the surface and subsurface of the specimens were measured as well as fluctuating acoustic pressures inside the insulation material. For the life test, the same sweep of the flap angle was made at a constant dynamic pressure of 900 psf and a constant Mach number of 1.8 for a total cumulative time of 200 minutes, equivalent to 400 missions.

This investigation was the second of a two-phase development test program where the first phase (OS304A) was conducted in the ARC 11-foot transonic wind tunnel and was reported separately (DMS-DR-2501).

This report presents information on the conduct of the test; descriptions of the test fixture, of the specimens, and of the test facility instrumentation particulars; and a sample of the pressure data collected during the test. Pre-test and post-test pictures of the specimens are included.

NOMENCLATURE

SYMBOL	MNEMONIC	DEFINITION
C_p	CP	Pressure coefficient
DB	DB	Decibel representation of P_{RMS}
M	MACH	Freestream Mach number
P_∞	P	Freestream static pressure, psf
P_ℓ	PL	Local static pressure, psia
P_{RMS}	PRMS	RMS value of the variations from the mean value of the local pressure, psi
P_t	PT	Freestream total pressure, psf
q	Q	Freestream dynamic pressure, psf
R_e	RE	Freestream Reynolds number, per ft
T_s	TS	Freestream static temperature, ^oR
T_t	TT	Freestream total temperature, ^oF
V_∞	VEL	Freestream velocity, ft/sec
X	X	Longitudinal distance positive, includes aft of round insert at flap trailing edge
Y	Y	Lateral distance positive, inches right of fixture centerline
α_F	FLAP	Test fixture flap setting, degrees
P	RHO	Freestream density, slugs/ft^3

Other symbology includes,

AFRSI	Advanced Flexible Reusable Surface Insulation
LRSI	Low Temperature Reusable Surface Insulation
IML	Inner Mold Line
OML	Outer Mold Line
OMS	Orbiter Maneuvering Subsystem

RTV	Room Temperature Vulcanizing (bonding material)
TOC	Time on Condition
VHT	Very High Temperature (silicon spray)

Specimen identification symbols:

2	9x7-foot wind tunnel
C	Calibration
T	Test (Life)
L	Light cover
H	Heavy cover

REMARKS

Random malfunctions of static pressure instrumentation were observed during the test.

1. Run 5 (Pad 2TL). Taps No. 5 and 11 on the fixture behaved erratically during the first 132 minutes of the run. Pressure data from these two orifices should be disregarded in the first 13 data sets of this run, including the first set with the flap at 46.6 degrees.

2. Run 7 (Pad 2TH). Tap No. 11 yielded faulty readings throughout the run.

3. Runs 9, 10, 11 (Pad 2CH). Tap No. 14 malfunctioned during those three runs.

Test pad 2CL lost approximately one square inch of insulation material near the center of the pad after three minutes into calibration run No. 2 at q = 700 psf. Testing was continued in order to obtain as much data as possible from the undamaged areas. The specimen continued losing material very slowly for some 30 minutes. The bulk of the damage to the pad occurred with about one minute to go in run No. 3 at 900 psf.

All test objectives were met. Although hardly visible in the photograph, the heavy fabric specimen (2TH) did lose a small amount of insulation material after 97 minutes (194 missions) of the planned 200-minute life test. The light surfaced test article failed after 150 minutes (300 missions).

REMARKS (Concluded)

A relatively large variation was observed in the height of the forward facing step on the diagonal joint of the specimens tested. The step on test pad 2TL measured 1/8 inch while the one on specimen 2TH was 1/4 inch. This variation may account for the fact that for the first time in this series of AFRSI wind tunnel tests, a light-covered specimen outlasted a heavy-covered article of similar design. Pre-test and post-test pictures of the four specimens tested are shown in Figures 8a through 8h.

No appreciable difference was detected between the surface and subsurface static pressure measurements on either calibration specimen.

CONFIGURATIONS INVESTIGATED

Model Description

A modified version of model 81-Ø (Drawing L014-01496) was employed for this test. The model 81-Ø fixture, located in the ceiling of the tunnel, consists of a 12-inch chord-flap with a 100-inch span, mounted at the trailing edge of a specimen-holding frame, and a sealed pressure box enclosing the space above the holding frame. The modification consisted of replacing part of the plenum box with two ceiling hatch covers, in effect reducing the volume of the plenum. The pressure box was vented to the tunnel test section to permit pressure equalization across the test pads.

Deflection of the hydraulically actuated flap produces a pressure disturbance upstream of the flap, which results in a thickening of the boundary layer. This in turn, deflects the flow from its original freestream direction and creates a reverse flow region near the boundaries in the flap/surface corner. In the area where boundary layer separation occurs, an unsteady shock wave is formed which gives rise to a large step-type positive pressure gradient and high turbulence levels (see Figure 1). The shape of the pressure distribution and the values of the pressure coefficients (shock strength) in the region of the separation depend on both the Mach number and the Reynolds number. For a given combination of these two numbers, the flow separation point on the specimen is determined by the flap angle. For this test, Mach and q were selected to yield shock strengths of 1.13 to 1.78 psi.

A 4.5-inch spacer was used together with shims to bring the leading and trailing edges of the specimen pads flush with the surface of the test fixture. The spacer/shim combinations employed are shown schematically in Figure 3. These were intended to compensate for the 6.77-inch depth of the supporting frame inside the test fixture.

Test Specimens

The AFRSI blankets consist of silica fiber felt (Q-felt) insulation material with a silica cloth face covering and a glass cloth back lining, all quilted together with quartz thread in a one-inch-square grid pattern. The quilting is done with a modified lock stitch. The outer covering or face sheet is made of either of two fabric weights: a "light cover" which is 0.010 inch thick (7 oz/sq. yard) or a 0.027 inch "heavy cover" (20 oz/sq. yard).

A total of four specimens were tested: two with light covers and two with the heavier face sheets. Of each pair, one specimen was instrumented to calibrate the flow at the surface and subsurface of the AFRSI material.

The test pads consisted of framed AFRSI panels (24x24 inches) bonded with RTV to 3/4-inch aluminum support plates (43.0x27.5 inches), so that the stitching loops were imbedded in the bonding material. One-inch-wide rectangular wooden frames surrounded the AFRSI material. The frame/specimen interfaces were closed off with aluminum retainer strips which covered the top surface of the frames and extended one inch over the blanket material, leaving an exposed AFRSI surface of 20x20 inches. The retainer strip extensions were bonded to the top of the specimen material to prevent puffing and possible damage to the blankets. A diagonal AFRSI joint with a forward facing step characterized all four test articles. The height of the step was not uniform for all specimens, but varied from approximately 1/8 inch to 5/16 inch. Wooden blocks (16x24 inches) were butted against the trailing edge of the AFRSI panels to fill the unoccupied space on the support plates. The surface of these blocks was tapered toward the trailing edge to a thickness equal to that of the leading edge. A sketch of a test specimen assembly is shown in Figure 2.

The test pads were fabricated according to drawing SD-AFRSI-WTDT-1. The specimen identification nomenclature was as follows:

2CH: 9x7-foot SWT/Calibration/Heavy cover

2CL: 9x7-foot SWT/Calibration/Light cover

2TH: 9x7-foot SWT/Life Test/Heavy cover

2TL: 9x7-foot SWT/Life Test/Light cover

This group of four test pads together with the four that were tested in OS304A was designated model 116-Ø.

A picture of a test specimen installed in model 81-Ø test fixture is shown in Figure 7.

INSTRUMENTATION

The model test fixture and the two calibration specimens, 2CH and 2CL, were instrumented with static pressure taps and fluctuating pressure transducers. The general layout is shown in Figures 4a and 4b while the nominal and actual location coordinates of the instrumentation are listed in Tables I, IIa, and IIb.

Static Pressure

The test fixture was instrumented with 23 static pressure taps: 16 on one side and 7 on the other. Each of the 2 calibration pads was instrumented with 30 surface taps and 10 subsurface taps, one of which (#409) was located on the diagonal joint.

Each surface pressure tap on a specimen consisted of 0.042-inch OD steel tubing which came up through the support plate, extended through the insulation material, and was brazed to a brass flanged collar affixed to the cloth surface covering of the specimen. Beneath the support plate, each steel tube was attached to a piece of flex tubing contained in a small, separate pressure cup attached to the plate bottom. Sufficient flex tubing was available to permit motion of the surface material. In order to isolate the pressures on either side of the plate, the tubes exited from their individual pressure cups through sealed apertures.

The subsurface taps consisted of the same size steel tubing protruding approximately 1/8 inch above the support plate, into the lower strata of the AFRSI material. Details of the instrumentation installation are shown in Figure 5.

The actual location of the pressure taps was dictated to a large extent by the stitching alignment on the specimens. In many cases, the specified tolerance of ±0.5 inch from the nominal locations was unavoidably exceeded. On test pad 2CL, tap No. 306 was deleted because of the crowded condition in its proposed location.

Fluctuating Pressure

The test fixture was instrumented with six Kulite fluctuating pressure transducers aligned on the right side of the fixture. Each of the calibration pads was instrumented with three Kulite transducers. These were inserted in the support plates and protruded approximately 1/4 inch into the insulation felt material (see Figure 5).

TEST FACILITY DESCRIPTION

The 9x7-Foot Supersonic Wind Tunnel is one of the supersonic legs of the Ames Unitary facility. It is a closed-circuit, variable-density, continuous-flow tunnel. The test section is 9 feet wide by 7 feet high by 18 feet long and the nozzle is of the asymmetric, sliding-block type, in which the variation of the test section Mach number is achieved by translating, in the streamwise direction, the fixed contour block that forms the floor of the nozzle. The temperature is controlled by after-cooling. Dry air for use in the circuit is supplied from four 30,000 cubic-foot spherical tanks. The tunnel drive motors and compressor also serve the 8 by 7-foot tunnel. The motors have a combined output of 180,000 horsepower for continuous operations or 216,000 horsepower for one hour of operation.

TEST PROCEDURE

The test conditions were divided into two general categories: calibration testing and life testing. All test runs in both categories were conducted at a constant Mach number of 1.8.

Calibrations

For each calibration pad, pressure data were obtained for 10 specified trailing flap angle settings between 32.8 and 55.7 degrees, for each of 3 dynamic pressures: 500, 700, and 900 psf.

Life Tests

These tests were carried out at a constant dynamic pressure of 900 psf, while the flap angle was changed from 32.8 to 55.7 degrees at 10 specified settings. Both specimens were subjected to the stipulated flow conditions for a cumulative time of 200 minutes apportioned equally between each flap angle. Cumulative time was measured from the point at which an initial q of 400 psf was reached. Testing was aborted if and when the specimen failed.

A summary of the runs completed including the test conditions and the time-on condition for each specimen is shown in Table III.

DATA REDUCTION

Standard tunnel equations were used to compute all tunnel conditions.

Local static pressure data were reduced to standard coefficient form,

$$C_p = (P_\ell - P_\infty) \times 144/q$$

RMS fluctuating pressure data were reduced to coefficient form and to DB form,

$$DB = 10 \log_{10} \left[\frac{P_{RMS} \times 10^9}{2.9007} \right]^2$$

These data were recorded continuously on magnetic tape and analyzed by Rockwell's Vibration and Acoustics unit (Dept. 380).

A typical data output printout is shown in Figures 6a through 6e.

REFERENCES

1. STS81-0447, "Pretest Information for the AFRSI OMS Pods/Joints Development Tests OS304A/B in the Ames Research Center (ARC) 11x11-Foot and 9x7-Foot Wind Tunnels Using Models 96-Ø and 81-Ø," June 1981.

TABLE 1

INSTRUMENTATION LOCATION
MODEL 81-0 FIXTURE

STATIC PRESSURES

TAP NO.	X	Y
101	2	-14.62
103	6	
105	10	
109	14	
113	18	
117	22	
121	26	
201	2	14.62
203	6	
205	10	
207	12	
209	14	
211	16	
213	18	
215	20	
217	22	
219	24	
221	26	
222	28	
224	30	
225	32	
227	34	
228	36	

FLUCTUATING PRESSURES

KULITE NO.	X	Y
K1	5	14.62
K2	9	
K3	11	
K4	13	
K5	15	
K6	19	

TABLE IIa

INSTRUMENTATION LOCATION
SPECIMEN 2CL

SURFACE

TAP NO.	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
101	1		1.00	6.05
102	3		2.80	6.15
103	5		5.00	6.15
104	6.5		6.10	5.65
105	7		7.10	6.05
107	9		9.25	6.05
109	11		11.40	5.95
110	13		13.60	5.90
111	15		15.80	5.90
113	19		19.00	6.25
301	1	0	1.00	-0.40
302	3		2.80	-0.40
303	5		5.10	-0.35
305	7		7.30	-0.35
306	8		-	-
307	9		8.60	-0.70
308	9.5		10.10	-0.15
309	11		11.20	-0.65
310	13		13.00	0.15
312	17		17.50	
313	19		19.70	
501	1	-6.0	1.00	-6.05
503	5		4.65	-6.10
505	7		6.85	-6.10
507	9		9.00	-6.05
509	11		11.20	-6.05
510	13		13.10	-6.25
511	15		15.10	-6.35
512	17		17.00	-5.55
513	19		19.20	-5.65

SUBSURFACE

TAP NO.	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
203	5	3.0	4.60	2.75
205	7		6.80	2.75
207	9		9.60	2.85
209	11		10.90	2.45
210	13		13.10	2.45
403	5	-3.0	5.10	-2.55
405	7		7.30	-2.55
407	9		8.60	-2.95
409	11		11.05	-3.05
410	13		13.45	-2.90

FLUCTUATING PRESSURES

NO.	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
K601	6	0.25	6.00	0.15
K602	8		8.20	0.15
K603	10		9.70	0.75

TABLE IIb

INSTRUMENTATION LOCATION
SPECIMEN 2CH

SURFACE

TAP NO.	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
101	1	6.0	1.00	6.00
102	3		3.00	6.00
103	5		5.20	6.10
104	6.5		6.05	5.75
105	7		7.20	6.15
107	9		9.10	6.00
109	11		11.35	5.95
110	13		12.65	5.50
111	15		14.90	5.50
113	19		18.90	6.35
301	1	0	1.00	0.05
302	3		2.55	0.20
303	5		4.75	0.25
305	7		6.80	0.35
306	8		8.30	-0.10
307	9		9.10	0.25
308	9.5		10.30	-0.15
309	11		10.90	0.20
310	13		13.10	0.15
312	17		16.65	-0.25
313	19		18.90	-0.35
501	1	-6.0	1.00	-6.00
503	5		4.75	-6.45
505	7		6.95	-6.45
507	9		8.70	-5.55
509	11		10.90	-5.55
510	13		13.00	-5.55
511	15		14.85	-5.65
512	17		17.00	-5.65
513	19		19.30	-5.65

SUBSURFACE

TAP NO.	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
203	5	3.0	4.80	2.50
205	7		6.90	2.55
207	9		9.60	2.85
209	11		10.50	3.25
210	13		12.65	3.30
403	5	-3.0	5.20	-2.90
405	7		7.40	-2.85
407	9		8.70	-3.35
409	11		11.00	-3.00
410	13		13.50	-2.95

FLUCTUATING PRESSURES

NO.	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
K601	6	0.25	5.70	0.75
K602	8		7.85	0.75
K603	10		10.50	1.05

TABLE III RUN SUMMARY

AFRSI OMS PODS/JOINTS DEVELOPMENT TEST

9x7 ARC

TEST: CS-3C4B

DATE: 29 JUNE 1981

DATA SET IDENTIFIER	CONFIGURATION	M	q	T.E. FLAP ANGLE ~DEG 32.8	34.7	37.2	41.6	43.0	45.0	46.6	49.5	52.3	55.7	TOC (MIN)
CALIB. TEST PADS														
	2CL	1.8	500	1										14
			700	2										22
			900	3										16
	2CH	1.8	500	9										11
			700	10										11
			900	11										11
LIFE TEST PADS														
	2TL	1.8	900	5							*			150*
	2TH	1.8	900	7					*					97*

TOC: TIME ON CONDITION

(for 2TL & 2TH, TIME @ q > 400 psf)

*FAILURE

TEST RUN NUMBERS

1 7 13 19 25 31 37 43 49 55 61 67 75 76

NASA-MSFC-MAF

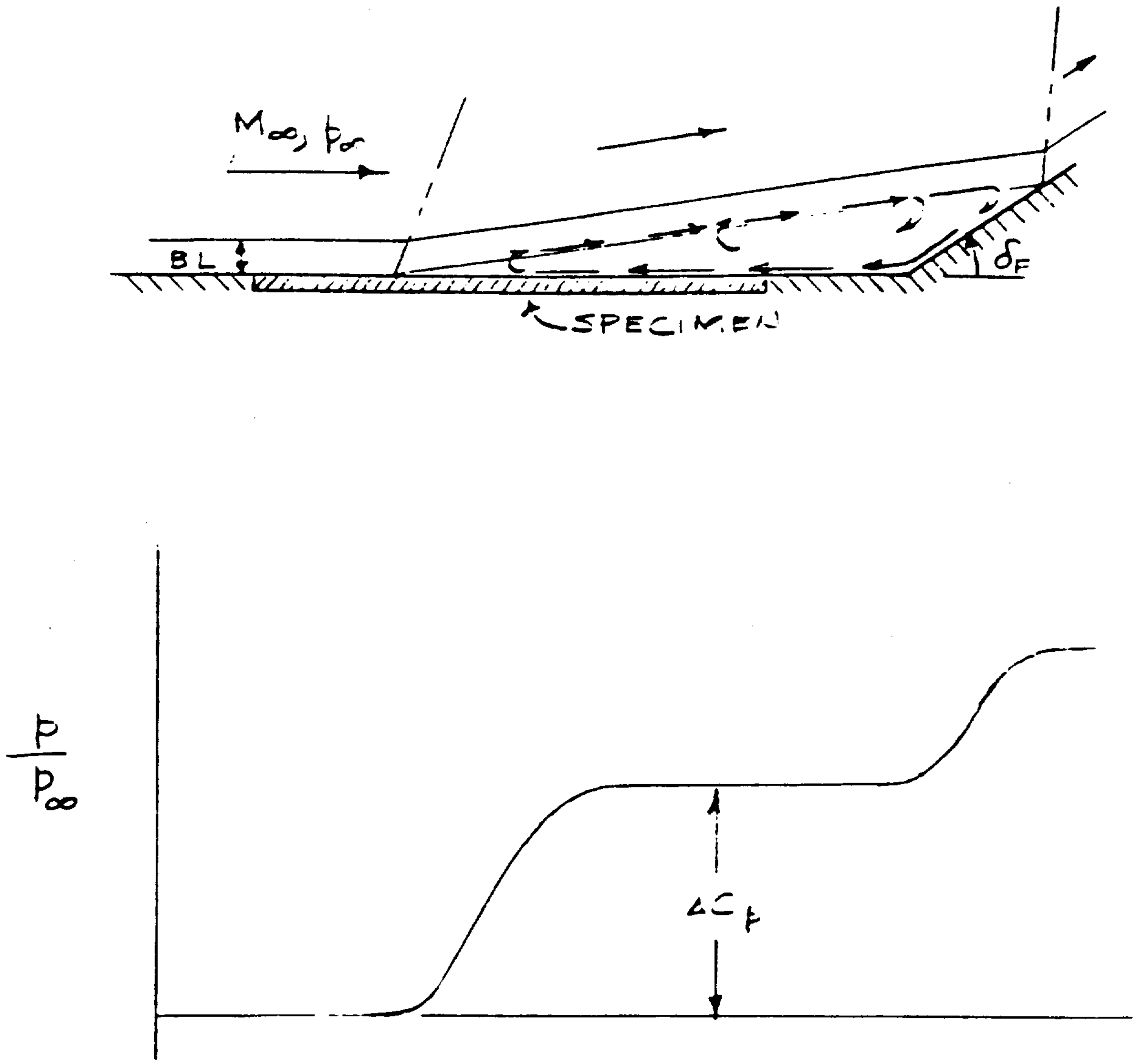


Figure 1
Typical Flow Field and Pressure Distribution
(Model 81-Ø)

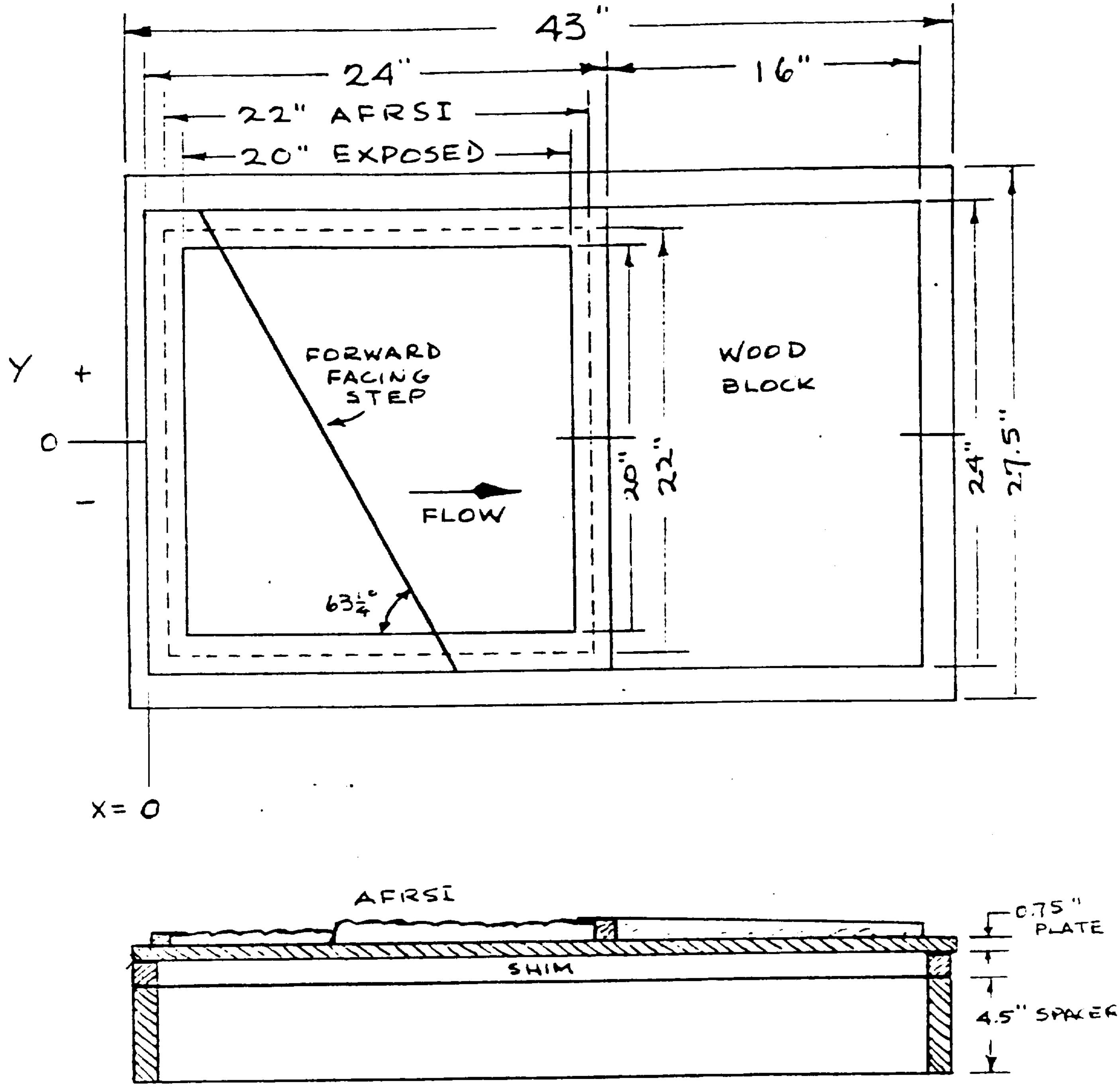


Figure 2
Model 116-Ø AFRSI Test Specimen Assembly

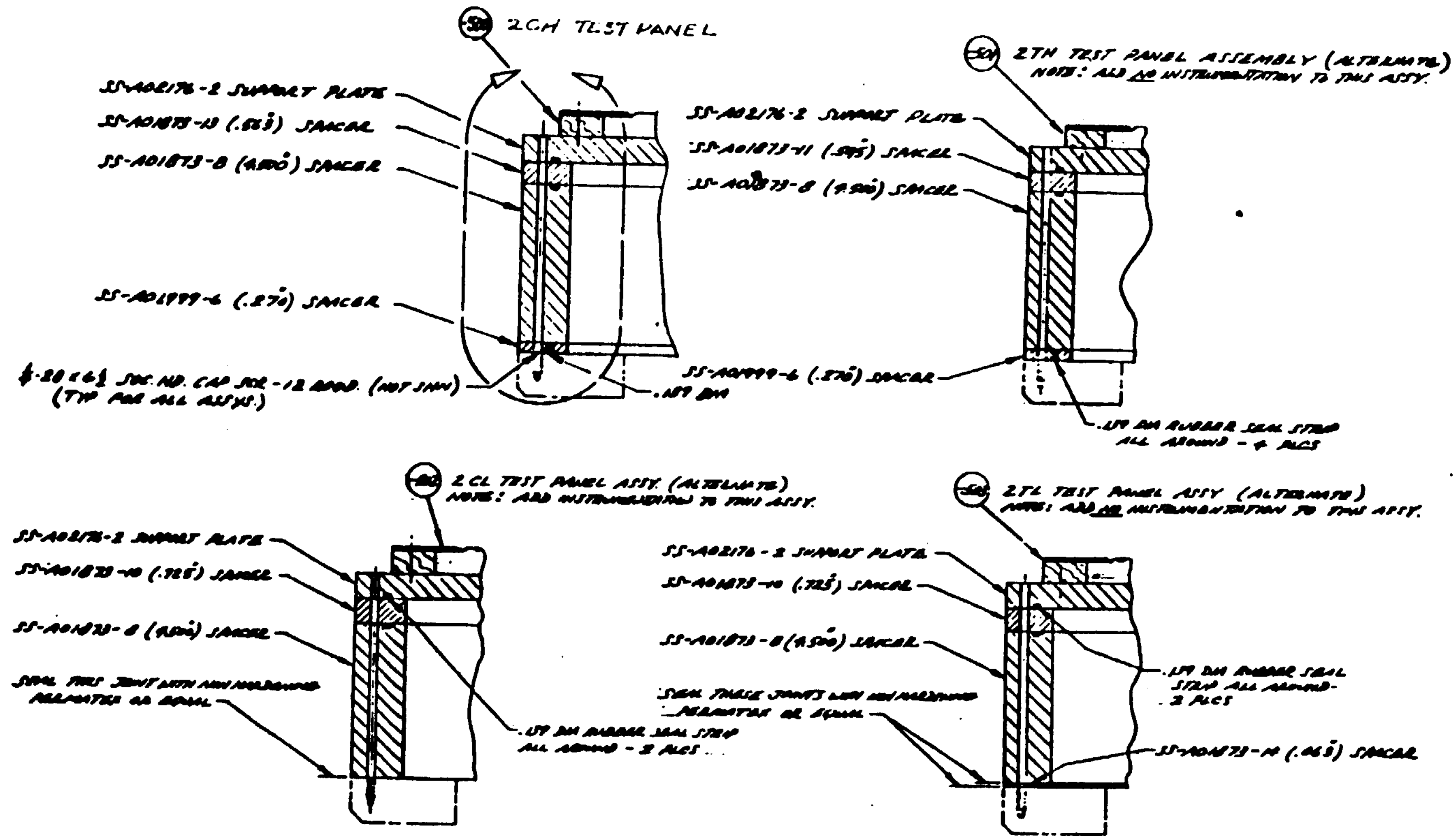


Figure 3. Shim/Spacers Combinations (OS304B)

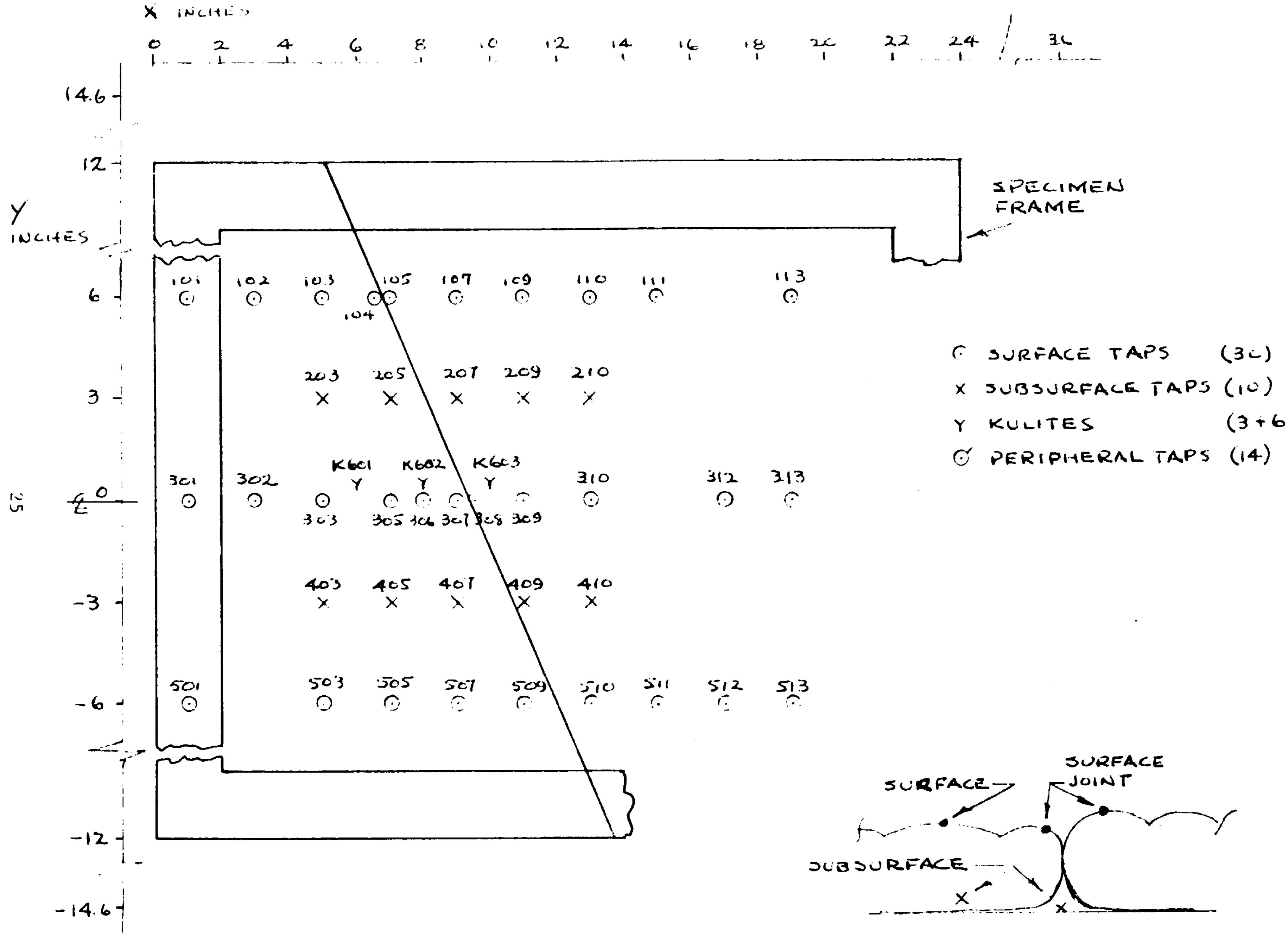


Figure 4a. Specimen Instrumentation (OS304B)

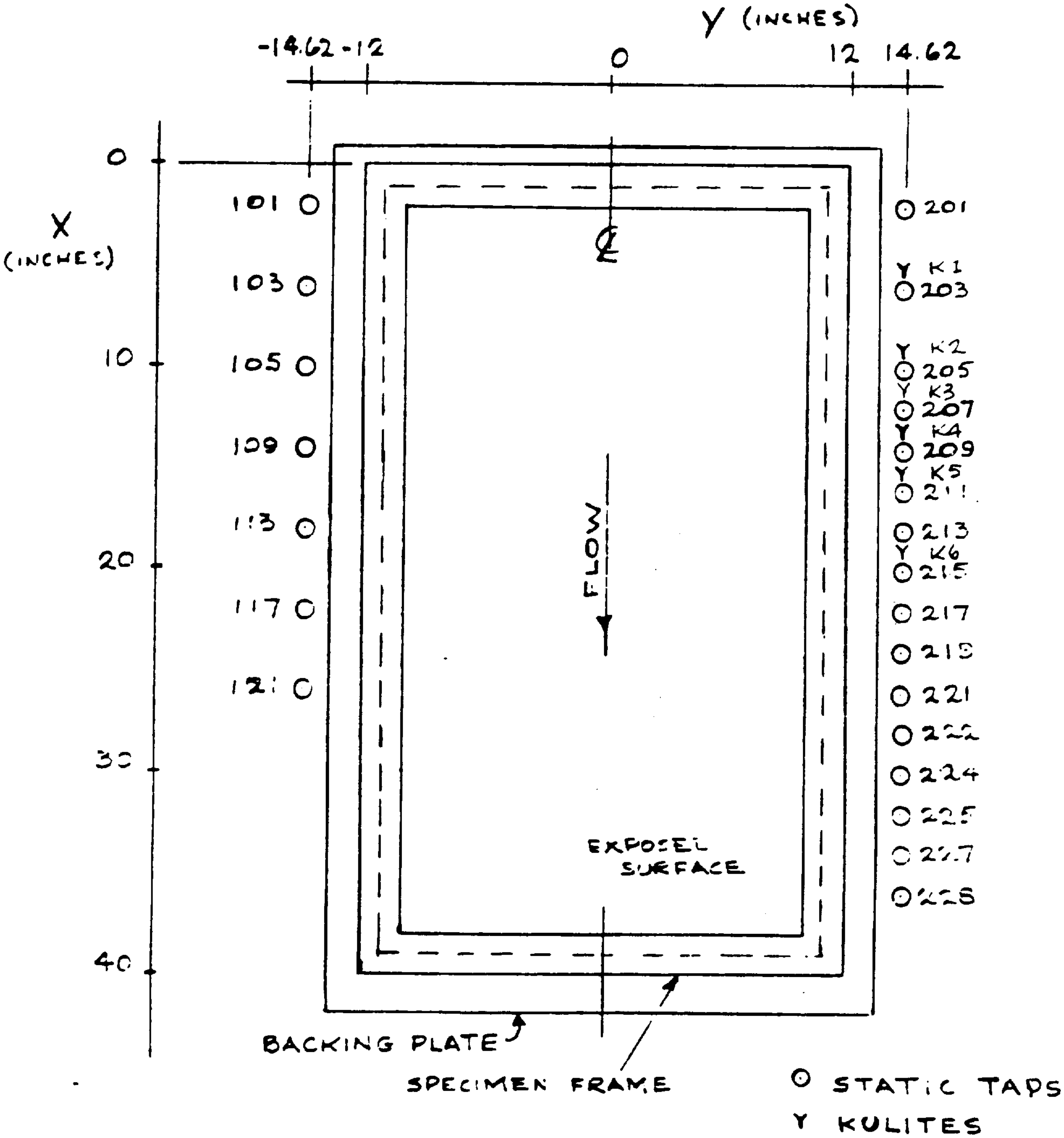


Figure 4b
Model 81-Ø Fixture Instrumentation
(OS304B)

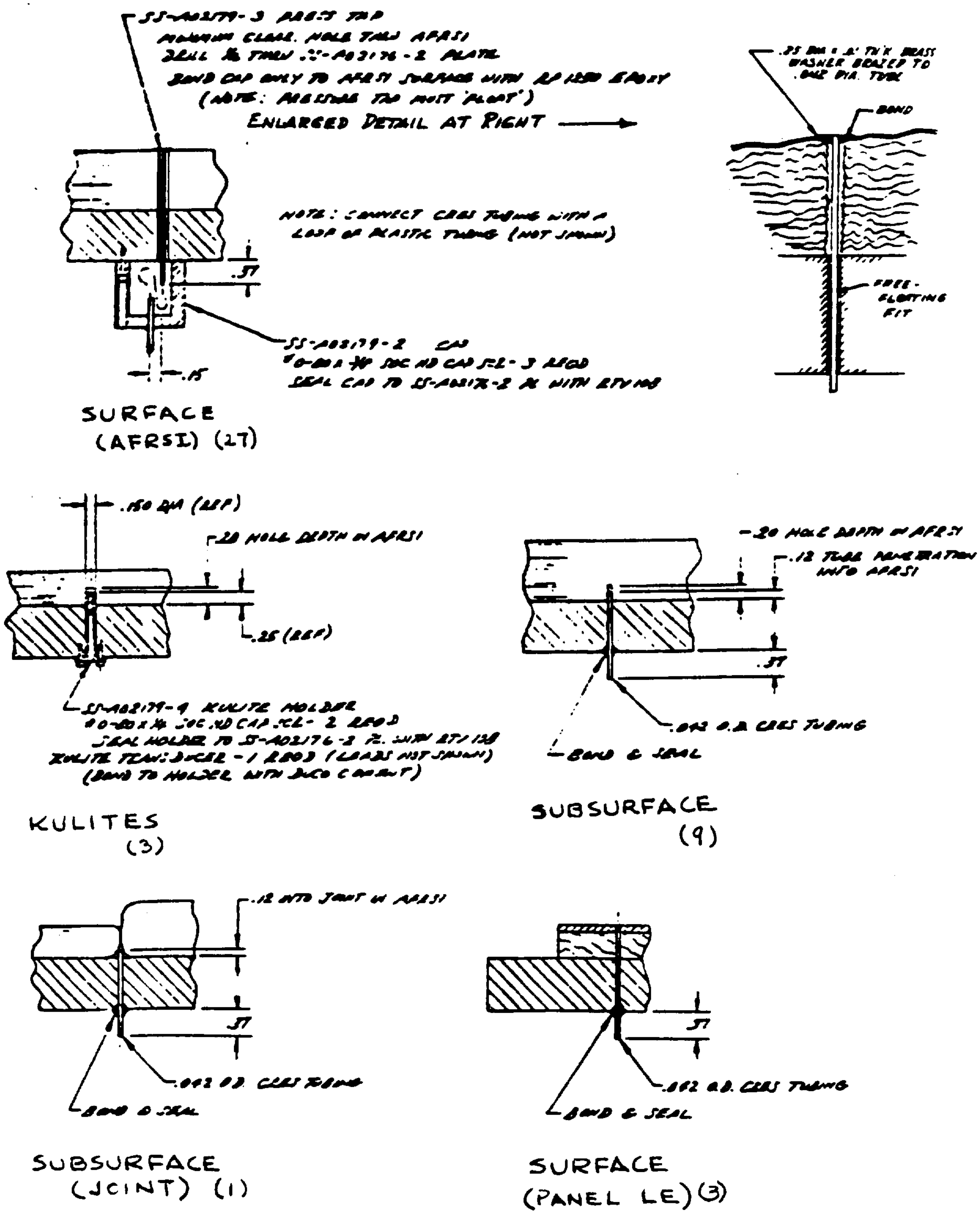


Figure 5
Instrumentation Details, Model 116-Ø
Specimens

RUN:SEQ TST P TN SCANNIVALVES REPORTED IN CP
1 4 501 1 97

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
						2CL		
1.800	497.8	1261.1	219.5	106.2	32.87	5	622	539

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	0.002			$$$$$$$			0.013
4.0		0.039		-0.030			
6.0	0.016	0.085	0.023	-0.023	0.022	0.025	0.008
7.0		0.141					
8.0		-0.103	0.128	0.088	0.050	-0.002	
9.0				0.010			
10.0	0.009	-0.004	-0.007	-0.133	0.059	0.045	-0.001
11.0				-0.073			
12.0	0.005	-0.019	-0.012	-0.016	0.104	0.032	
13.0							
14.0	0.010	-0.009	0.008	0.000	0.032	0.032	0.015
16.0	0.014	-0.027				0.023	
18.0	-0.001			0.005		-0.001	0.029
20.0	0.015	0.030		-0.005		0.015	
22.0	0.017						0.023
24.0	0.025						
26.0	0.064						0.158
28.0	0.176						
30.0	0.223						
32.0	0.234						
34.0	0.318						
36.0	0.241						

RUN:SEQ TST P TN SCANNIVALVES REPORTED IN CP
1 5 501 1 97

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	497.8	1261.1	219.5	106.5	34.76	5	622	541

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	-0.003			$$$$$$$			0.011
4.0		0.037		0.029			
6.0	0.017	0.084	0.021	0.021	0.020	0.027	0.006
7.0		0.137					
8.0		-0.105	0.130	0.090	0.049	-0.003	
9.0				0.003			
10.0	0.007	-0.005	-0.009	0.129	0.055	0.043	0.000
11.0				-0.078			
12.0	0.005	-0.013	-0.017	-0.013	0.102	0.081	
13.0							
14.0	0.06[illegible]	-0.011	0.006	-0.002	0.027	0.031	0.017
16.0	0.015	-0.032				0.021	
18.0	-0.003			0.009		0.004	0.030
20.0	0.014	0.037		0.039		0.031	
22.0	0.021						0.075
24.0	0.075						
26.0	0.168						0.234
28.0	0.245						
30.0	0.265						
32.0	0.311						
34.0	0.334						
36.0	0.357						

Figure 6a.

Typical Data Output (OS304B)

RUN:SEQ TST P TN SCANNIVALVES REPORTED IN CP
1 6 501 1 97

2CL

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	497.2	1259.6	219.2	107.2	37.22	5	622	542

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	0.001			$$$$$$$			0.012
4.0		0.035		0.032			
6.0	0.020	0.035	0.025	0.025	0.021	0.027	0.007
7.0		0.140					
8.0		-0.101	0.131	0.090	0.047	0.000	
9.0				0.012			
10.0	0.011	-0.002	-0.005	0.129	0.059	0.041	0.001
11.0				-0.077			
12.0	0.007	-0.014	-0.016	-0.014	0.106	0.032	
13.0							
14.0	0.012	-0.010	0.007	-0.001	0.034	0.035	0.020
16.0	0.015	-0.022				0.025	
18.0	0.001			0.050		0.027	0.040
20.0	0.029	0.066		0.129		0.106	
22.0	0.030						0.188
24.0	0.183						
26.0	0.252						0.272
28.0	0.292						
30.0	0.295						
32.0	0.329						
34.0	0.355						
36.0	0.370						

RUN:SEQ TST P TN SCANNIVALVES REPORTED IN CP
1 7 501 1 97

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	497.9	1261.1	219.5	107.6	41.64	5	622	544

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	0.001			$$$$$$$			0.011
4.0		0.034		0.034			
6.0	0.017	0.034	0.025	0.025	0.020	0.027	0.003
7.0		0.139					
8.0		-0.099	0.130	0.090	0.043	0.003	
9.0				0.011			
10.0	0.010	-0.002	-0.006	0.128	0.058	0.040	0.004
11.0				-0.068			
12.0	0.006	-0.011	-0.014	-0.009	0.103	0.084	
13.0							
14.0	0.014	0.023	0.033	0.028	0.065	0.045	0.025
16.0	0.026	0.075				0.079	
18.0	0.075			0.182		0.153	0.036
20.0	0.185	0.199		0.237		0.202	
22.0	0.237						0.265
24.0	0.280						
26.0	0.314						0.317
28.0	0.331						
30.0	0.340						
32.0	0.354						
34.0	0.360						
36.0	0.395						

Figure 6b.

Typical Data Output (OS304B)

RUN:SEQ	TST	P	TN	SCANNIVALVES REPORTED IN CP
1 8	501	1	97	

2CL

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	497.5	1260.4	219.4	107.9	43.04	5	622	545

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	-0.002			$$$$$$$			0.008
4.0		0.034		0.034			
6.0	0.017	0.084	0.025	0.028	0.020	0.027	0.003
7.0		0.140					
8.0		-0.098	0.130	0.093	0.046	-0.000	
9.0				0.008			
10.0	0.011	-0.002	-0.005	0.129	0.053	0.040	0.000
11.0				-0.063			
12.0	0.012	-0.000	0.000	0.003	0.117	0.090	
13.0							
14.0	0.020	0.077	0.061	0.065	0.114	0.074	0.037
16.0	0.074	0.139				0.131	
18.0	0.147			0.220		0.197	0.168
20.0	0.217	0.234		0.257		0.231	
22.0	0.263						0.294
24.0	0.306						
26.0	0.329						0.329
28.0	0.340						
30.0	0.349						
32.0	0.369						
34.0	0.392						
36.0	0.407						

RUN:SEQ	TST	P	TN	SCANNIVALVES REPORTED IN CP
1 9	501	1	97	

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	497.2	1259.6	219.2	108.2	45.01	5	622	546

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	0.001			$$$$$$$			0.009
4.0		0.035		0.037			
6.0	0.017	0.084	0.028	0.025	0.020	0.027	0.002
7.0		0.143					
8.0		-0.090	0.134	0.093	0.049	0.003	
9.0				0.008			
10.0	0.019	0.010	0.017	0.131	0.064	0.046	0.004
11.0				-0.023			
12.0	0.027	0.060	0.052	0.066	0.140	0.104	
13.0							
14.0	0.060	0.149	0.110	0.148	0.171	0.132	0.066
16.0	0.163	0.194				0.200	
18.0	0.214			0.249		0.243	0.217
20.0	0.277	0.260		0.277		0.257	
22.0	0.291						0.309
24.0	0.329						
26.0	0.349						0.352
28.0	0.369						
30.0	0.358						
32.0	0.375						
34.0	0.404						
36.0	0.401						

Figure 6c.

Typical Data Output (OS304B)

RUN:SEQ	TST	P	TN	SCANNIVALVES REPORTED IN CP
1 10	501	1	97	

MACH	Q	PT	P	TTF	FLAP	2CL CONF	DATE	TIME
1.800	497.5	1260.4	219.4	108.2	46.58	5	622	547

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	-0.061			*******			0.012
4.0		0.032		0.040			
6.0	0.020	0.087	0.031	0.038	0.020	0.027	0.003
7.0		0.149					
8.0		-0.073	0.139	0.099	0.054	0.006	
9.0				0.014			
10.0	0.022	0.044	0.057	0.137	0.081	0.057	0.006
11.0				0.009			
12.0	0.056	0.137	0.103	0.103	0.166	0.133	
13.0							
14.0	0.157	0.206	0.147	0.174	0.205	0.180	0.154
16.0	0.217	0.222				0.234	
18.0	0.251			0.271		0.271	0.257
20.0	0.288	0.286		0.306		0.286	
22.0	0.311						0.302
24.0	0.343						
26.0	0.360						0.371
28.0	0.371						
30.0	0.375						
32.0	0.391						
34.0	0.403						
36.0	0.427						

RUN:SEQ	TST	P	TN	SCANNIVALVES REPORTED IN CP
1 11	501	1	97	

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	497.5	1260.4	219.4	108.6	49.45	5	622	549

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	0.001			*******			0.012
4.0		0.034		0.040			
6.0	0.026	0.105	0.051	0.048	0.034	0.030	0.006
7.0		0.160					
8.0		0.003	0.156	0.136	0.100	0.032	
9.0				0.017			
10.0	0.165	0.139	0.146	0.177	0.142	0.117	0.047
11.0				0.168			
12.0	0.199	0.206	0.183	0.209	0.217	0.191	
13.0							
14.0	0.263	0.249	0.205	0.248	0.263	0.251	0.249
16.0	0.297	0.263				0.289	
18.0	0.303			0.315		0.315	0.311
20.0	0.337	0.311		0.337		0.326	
22.0	0.349						0.363
24.0	0.366						
26.0	0.383						0.400
28.0	0.388						
30.0	0.404						
32.0	0.406						
34.0	0.426						
36.0	0.430						

Figure 6d.

Typical Data Output (OS304B)

RUN:SEQ		TST	P	TN
1	12	501	1	97

SCANNIVALVES REPORTED IN CP

2CL

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	497.2	1259.6	219.2	109.3	52.17	5	622	550

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	-0.003			$$$$$$$			0.012
4.0		0.044		0.040			
6.0	0.046	0.136	0.097	0.100	0.078	0.033	0.027
7.0		0.189					
8.0		0.117	0.185	0.188	0.186	0.123	
9.0				0.020			
10.0	0.223	0.220	0.226	0.220	0.194	0.186	0.211
11.0				0.220			
12.0	0.275	0.263	0.255	0.255	0.255	0.240	
13.0							
14.0	0.306	0.295	0.269	0.292	0.309	0.236	0.306
16.0	0.326	0.309				0.321	
18.0	0.324			0.349		0.338	0.343
20.0	0.357	0.349		0.372		0.349	
22.0	0.375						0.387
24.0	0.390						
26.0	0.397						0.433
28.0	0.417						
30.0	0.416						
32.0	0.429						
34.0	0.439						
36.0	0.447						

RUN:SEQ		TST	P	TN
1	13	501	1	97

SCANNIVALVES REPORTED IN CP

MACH	Q	PT	P	TTF	FLAP	CONF	DATE	TIME
1.800	496.9	1258.9	219.1	108.9	55.58	5	622	551

X-IN	Y=16	6	3	0	-3	-6	-16
2.0	0.015			$$$$$$$			0.025
4.0		0.101		0.081			
6.0	0.196	0.200	0.193	0.195	0.204	0.168	0.181
7.0		0.258					
8.0		0.246	0.255	0.255	0.275	0.249	
9.0				0.029			
10.0	0.304	0.289	0.305	0.286	0.284	0.226	0.295
11.0				0.292			
12.0	0.330	0.329	0.323	0.315	0.321	0.310	
13.0							
14.0	0.358	0.352	0.330	0.341	0.351	0.349	0.355
16.0	0.383	0.350				0.375	
18.0	0.387			0.387		0.390	0.391
20.0	0.404	0.392		0.406		0.398	
22.0	0.418						0.413
24.0	0.431						
26.0	0.435						0.441
28.0	0.449						
30.0	0.443						
32.0	0.452						
34.0	0.462						
36.0	0.459						

Figure 6e.

Typical Data Output (OS304B)

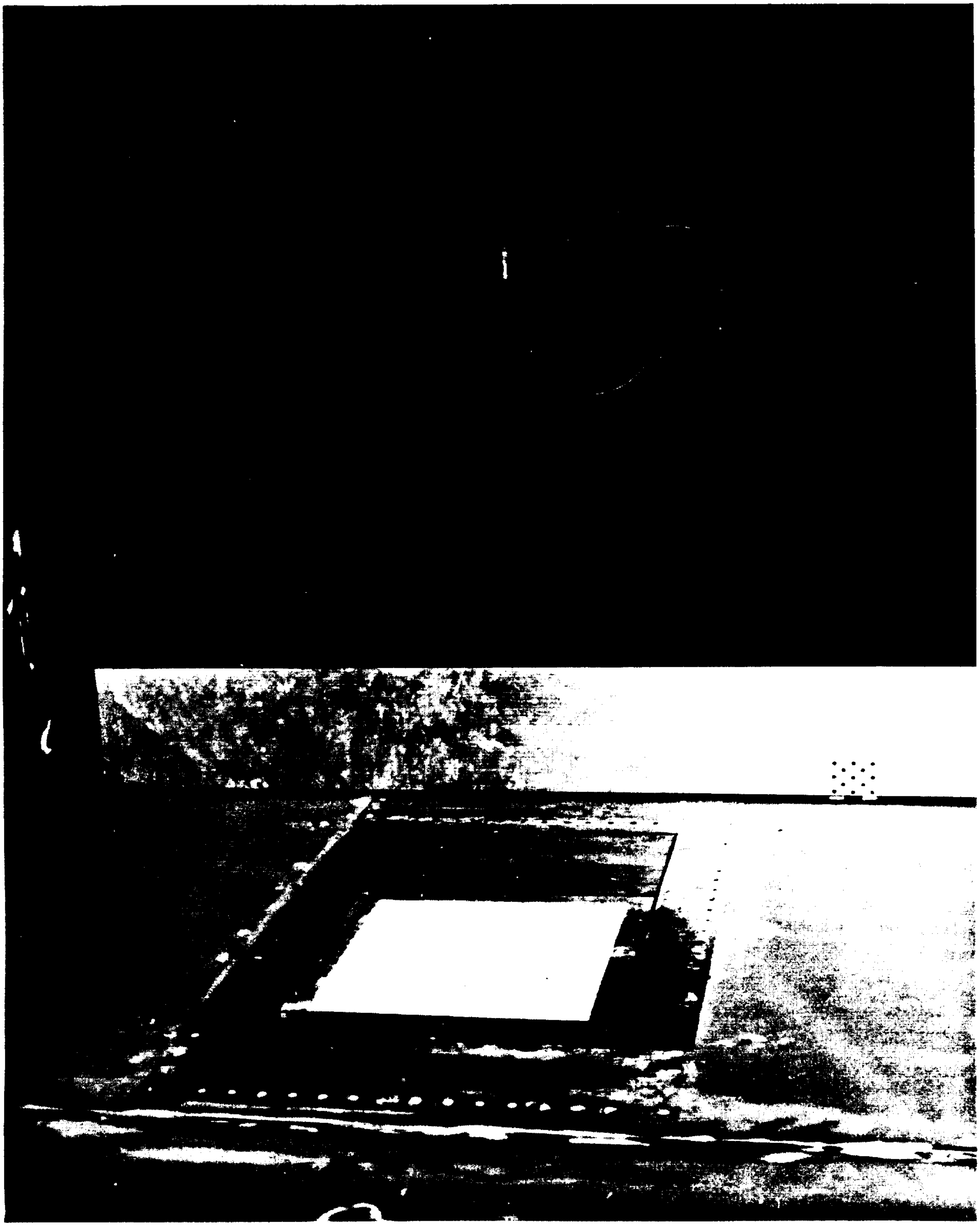
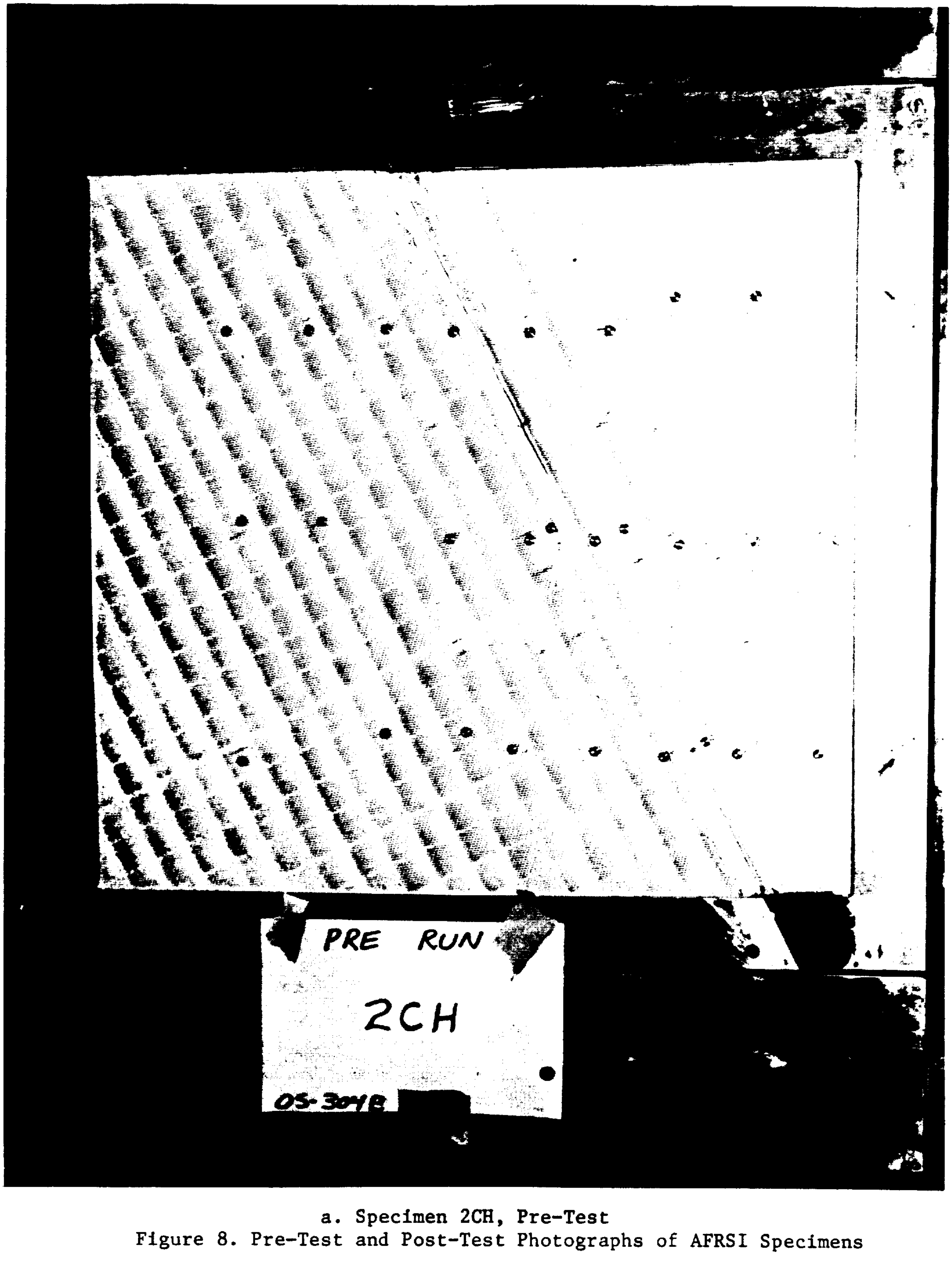
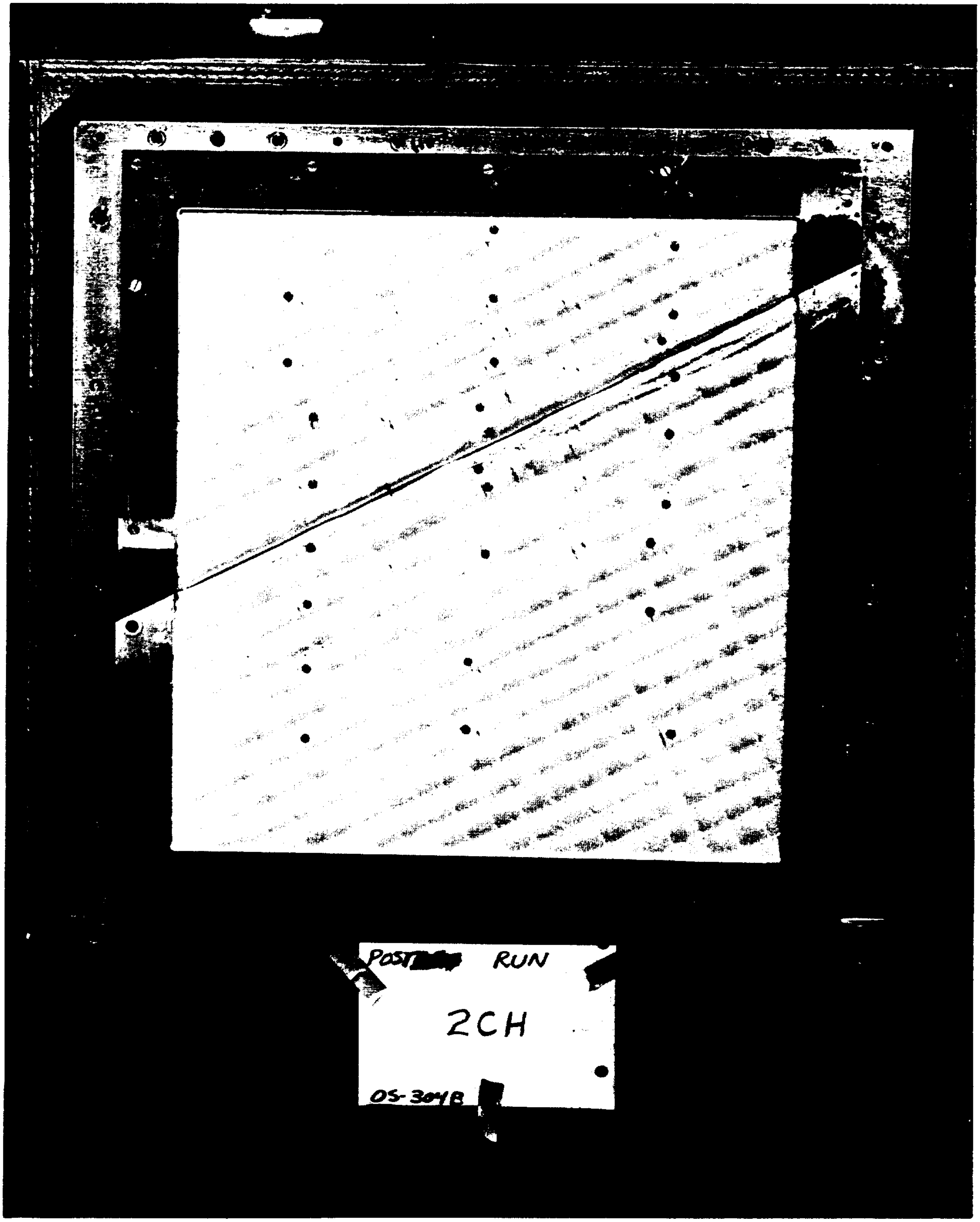


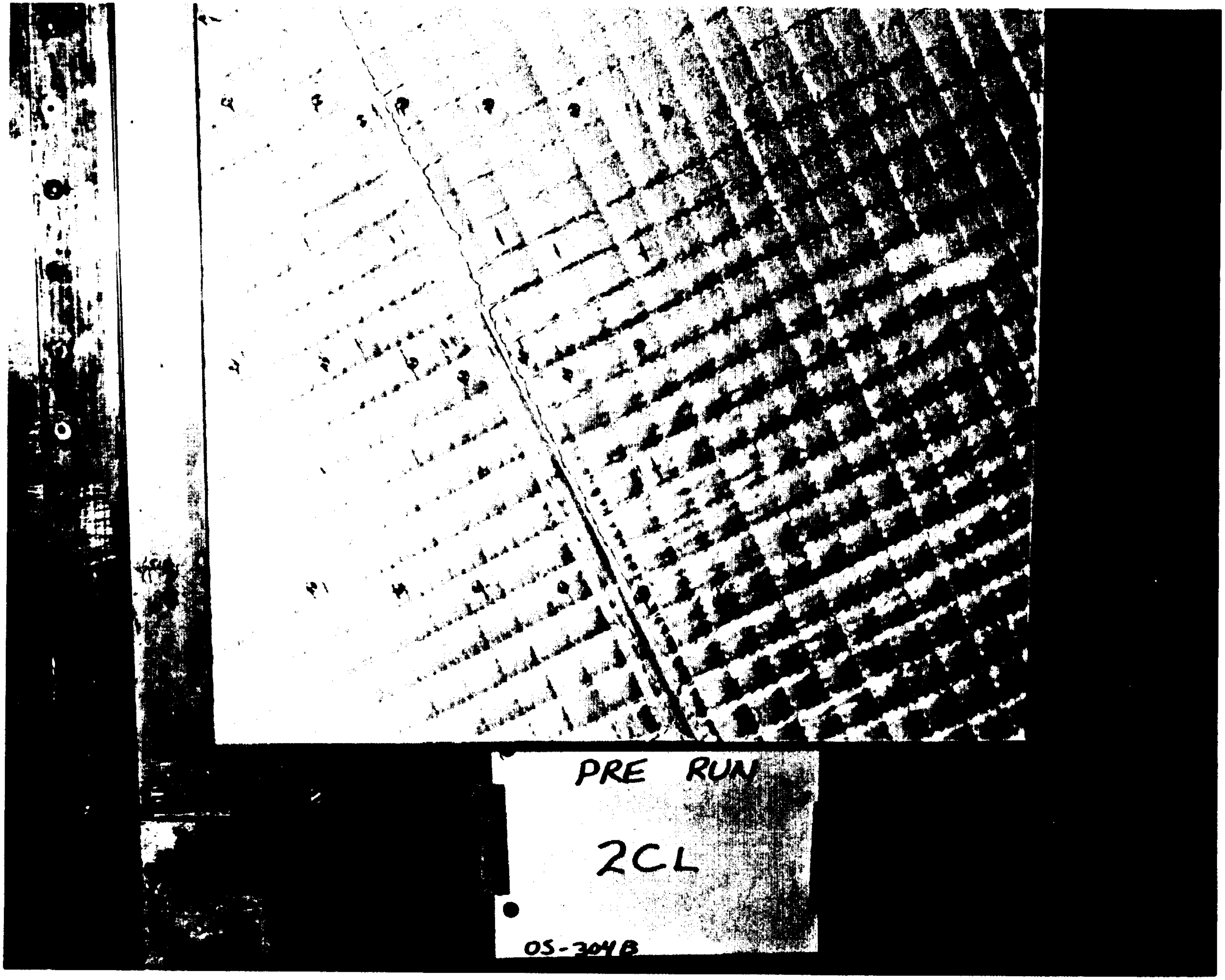
Figure 7. Installation Photograph



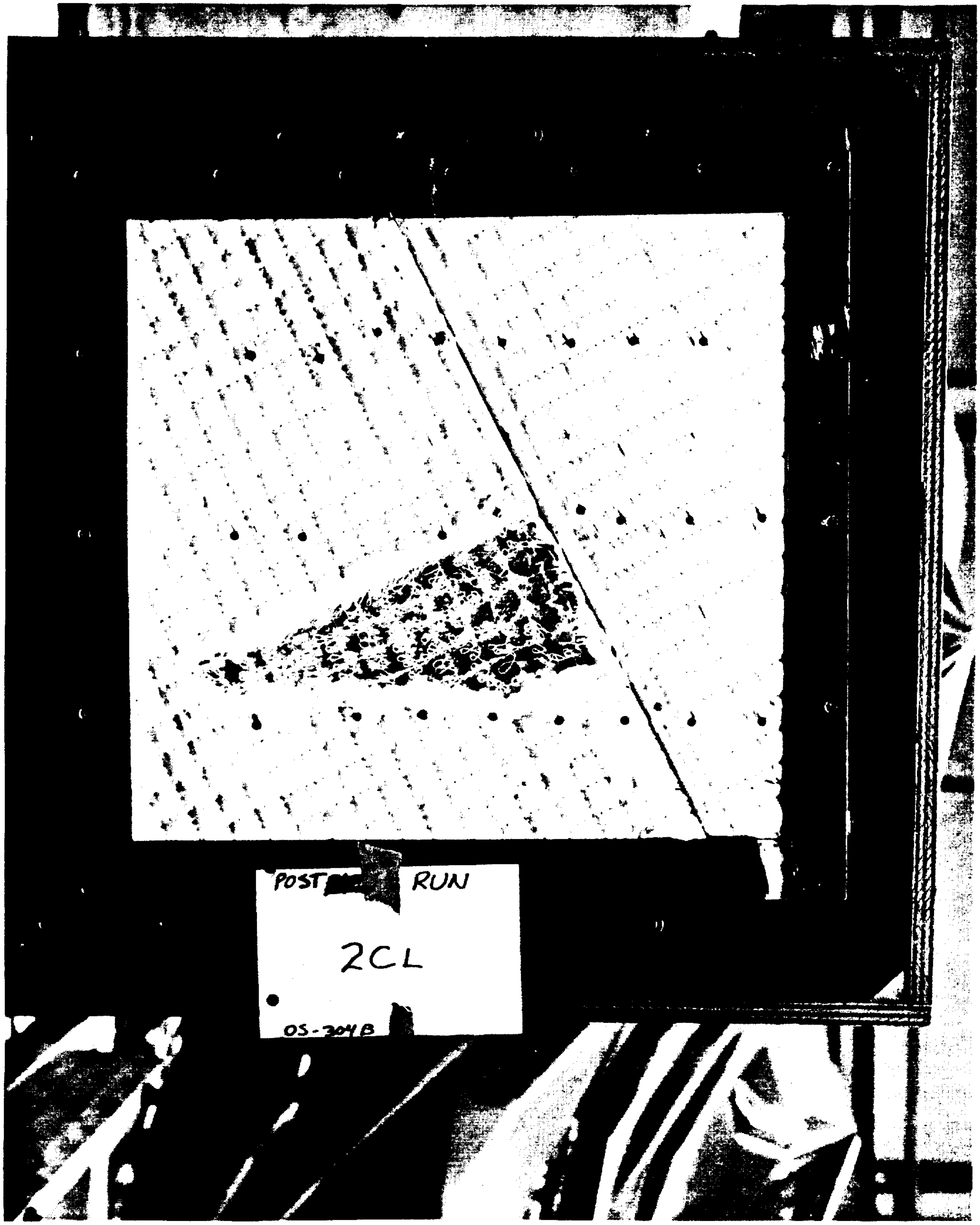
a. Specimen 2CH, Pre-Test
Figure 8. Pre-Test and Post-Test Photographs of AFRSI Specimens



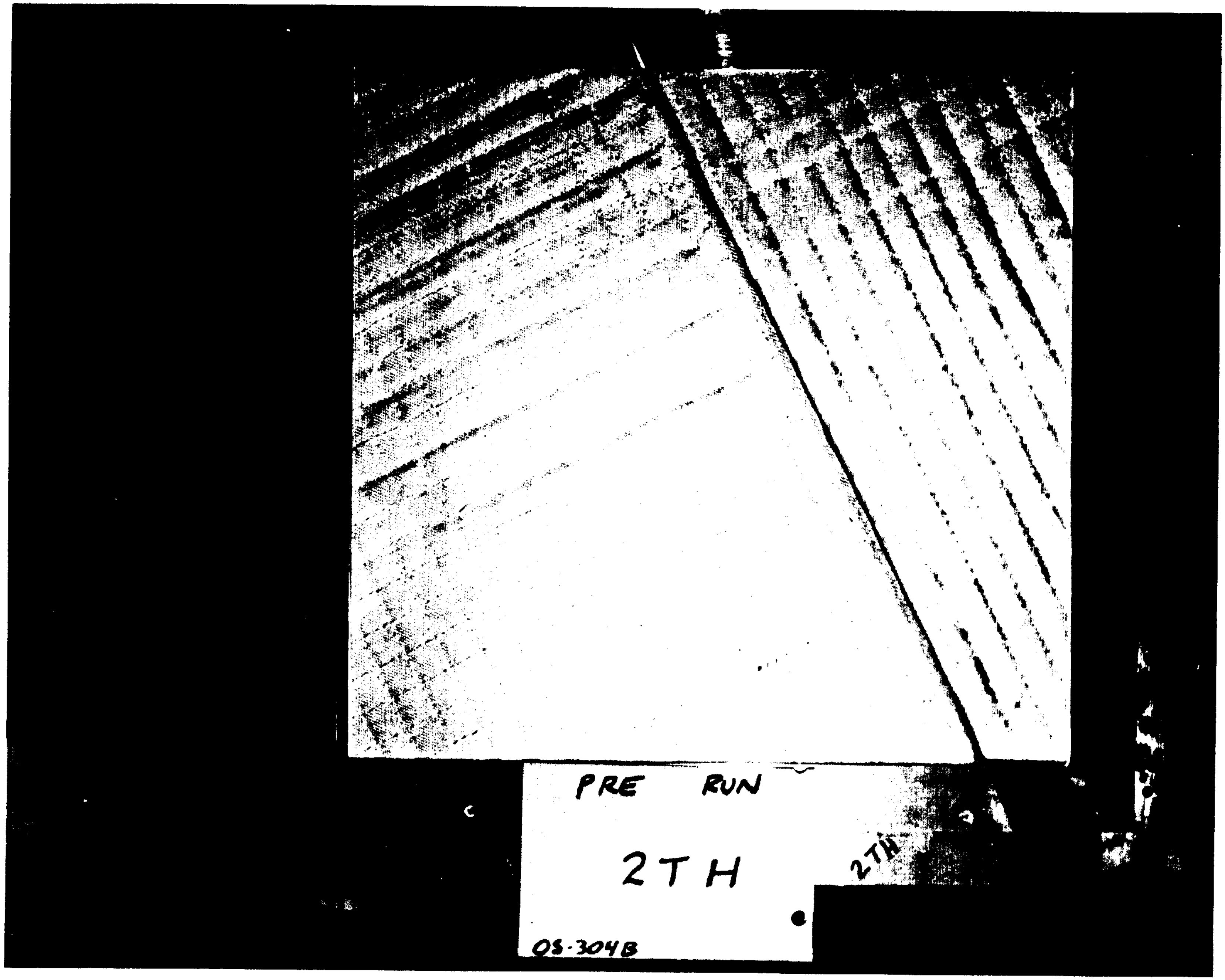
b. Specimen 2CH, Post-Test, Runs 9-11
Figure 8. (Continued)



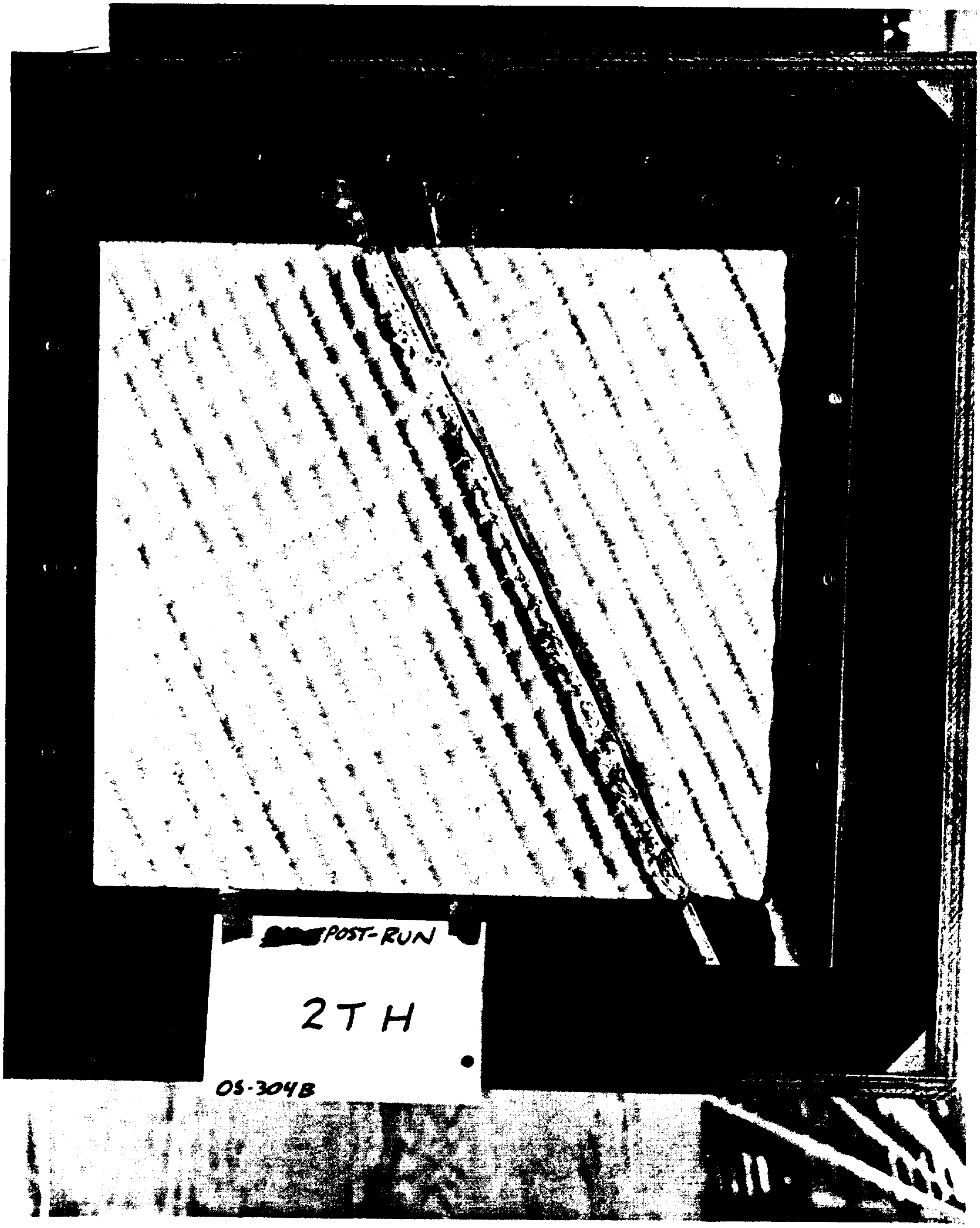
c. Specimen 2CL, Pre-Test
Figure 8. (Continued)



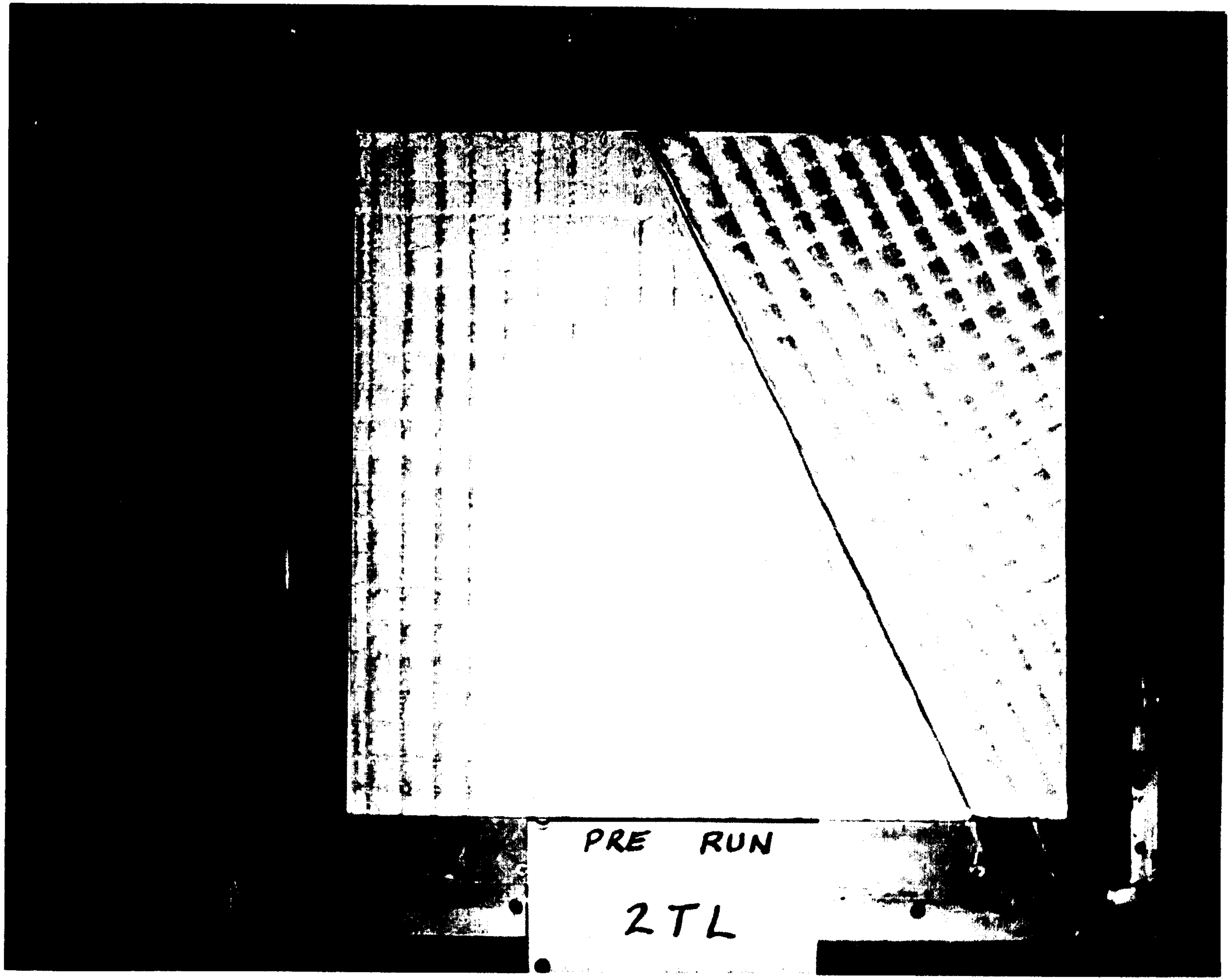
d. Specimen 2CL, Post-Test, Runs 1-3
Figure 8. (Continued)



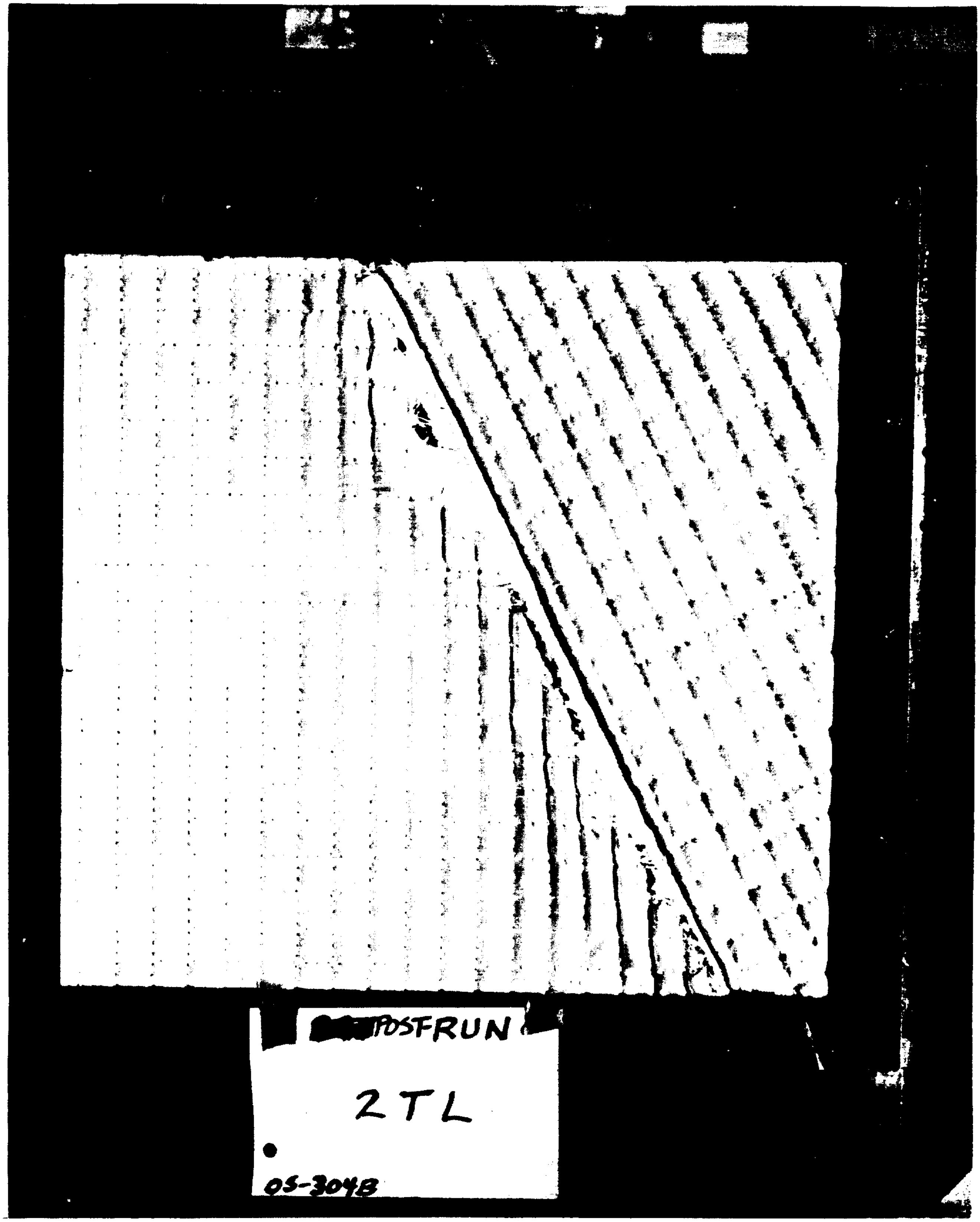
e. Specimen 2TH, Pre-Test
Figure 8. (Continued)



f. Specimen 2TH, Post-Test, Run 7
Figure 8. (Continued)



g. Specimen 2TL, Pre-Test
Figure 8. (Continued)



h. Specimen 2TL, Post-Test, Run 5
Figure 8. (Concluded)

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